# Renesas USB MCU

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Rev.1.11
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## USB Peripheral Human Interface Devices Class Driver Using Firmware Integration Technology Modules

## Introduction

This document describes the following sample firmware: USB Peripheral Human Interface Devices Class Driver for using Firmware Integration Technology. The sample firmware is referred to below as the PHID. During actual software development, make sure to refer to the USB Peripheral Human Interface Devices Class Driver f using Firmware Integration Technology application note (document No. R01AN2663EJ) in combination with the USB Basic Host and Peripheral Driver using Firmware Integration Technology application note (document No. R01AN2025EJ) and the user's manual (hardware) of the microcontroller used.

## Target Device

RX63N/RX631 Group
RX64M Group
RX71M Group

The operation of this program has been confirmed using the Renesas Starter Kit (RSK).

## Contents

# 1. Introduction

## 1.1 Functions

The PHID conforms to the USB human interface device (HID) class specification and implements communication with HID devices.

The PHID provides the following functionalities:

1. Operation as a Full-Speed (12 Mbps) device.
2. It is recognized as an HID device when connected to a USB host, and transfers data as a virtual mouse or virtual keyboard.

## 1.2 FIT Module Configuration

The PHID comprises the following FIT modules and a sample application:

**Table 1-1 FIT Module Configuration**

| FIT Module | Folder Name | Version |
|---|---|---|
| Board Support Package Module Using Firmware Integration Technology | r_bsp | 2.81 |
| Renesas USB MCU USB Basic Host and Peripheral firmware Firmware Integration Technology | r_usb_basic | 1.11 |
| Renesas USB MCU USB Peripheral Human Interface Devices Class Driver(HID) Firmware Integration Technology | r_usb_phid | 1.11 |

Refer to the related documentation for details of each FIT module. Note that the latest versions of the FIT modules used by the sample firmware are available for download from the following website:

Renesas Electronics website: http://www.renesas.com/

## 1.3 Operating Confirmation Environment

The environment required for the PHID to operate is described below:

1) Evaluation Board

Renesas Starter Kit+ for RX63N (RSK+RX63N): Product No: R0K50563NC000
RX63N Group Renesas Microcontroller Development Starter Kit from Renesas Electronics

Renesas Starter Kit+ for RX64M (RSK+RX64M): Product No: R0K50564MC010BR
RX64M Group Renesas Microcontroller Development Starter Kit from Renesas Electronics

Renesas Starter Kit+ for RX71M (RSK+RX71M): Product No: R0K5RX71MC010BR
RX71M Group Renesas Microcontroller Development Starter Kit from Renesas Electronics

2) Development Environment

a) e² studio integrated development environment, from Renesas Electronics
b) RX Family C/C++ compiler package, version 2.03.00, from Renesas Electronics
c) E1 or E20 emulator from Renesas Electronics

3) Other

a) HID Host (PC: Microsoft Windows® 7, Windows® 8, Windows® 8.1, or Windows® 10)
b) Host PC for emulator (Microsoft Windows® 7, Windows® 8, or Windows® 8.1)
c) USB cable
d) User cable (packaged with E1 or E20 emulator)
e) Emulator cable (packaged with E1 or E20 emulator)

## 1.4 Setup

### 1.4.1 Hardware

Figure 1-1 shows an example operating environment for the PHID. Refer to the associated instruction manuals for details on setting up the evaluation board and using the emulator, etc.

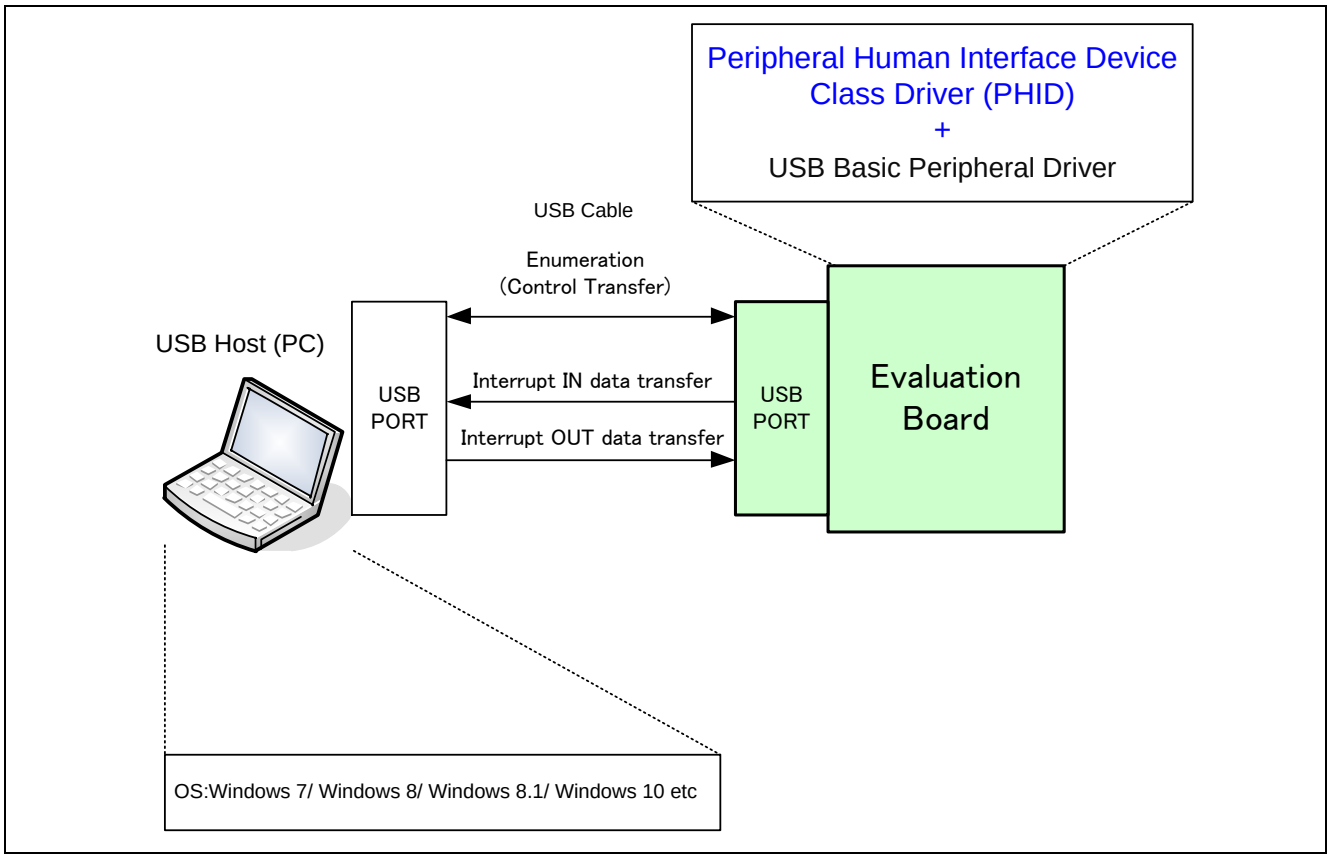



**Figure 1-1 Example Operating Environment**

Table 1-2 shows the evaluation board on which operation has been confirmed.

**Table 1-2 Evaluation Board on which PHID operation has been verified**

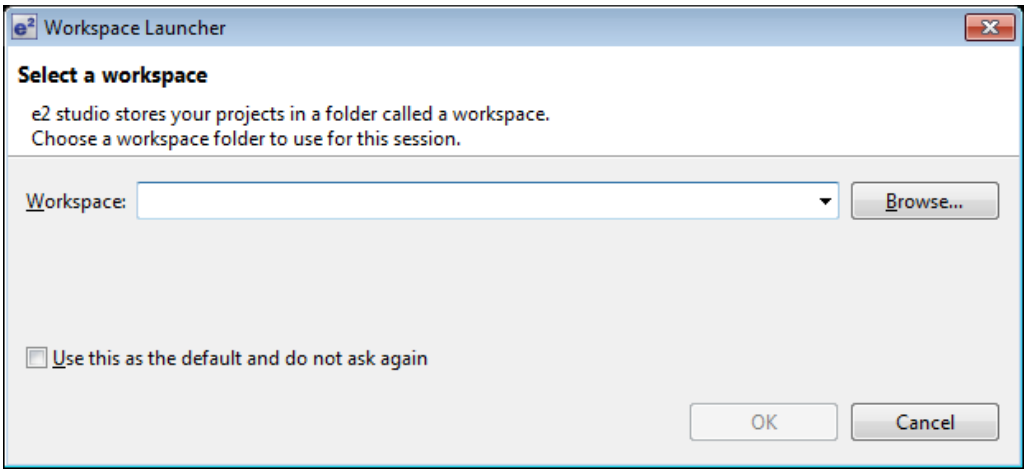
| MCU | Evaluation Board |
|---|---|
| RX63N | RSK+RX63N |
| RX64M | RSK+RX64M |
| RX71M | RSK+RX71M |

### 1.4.2 Software

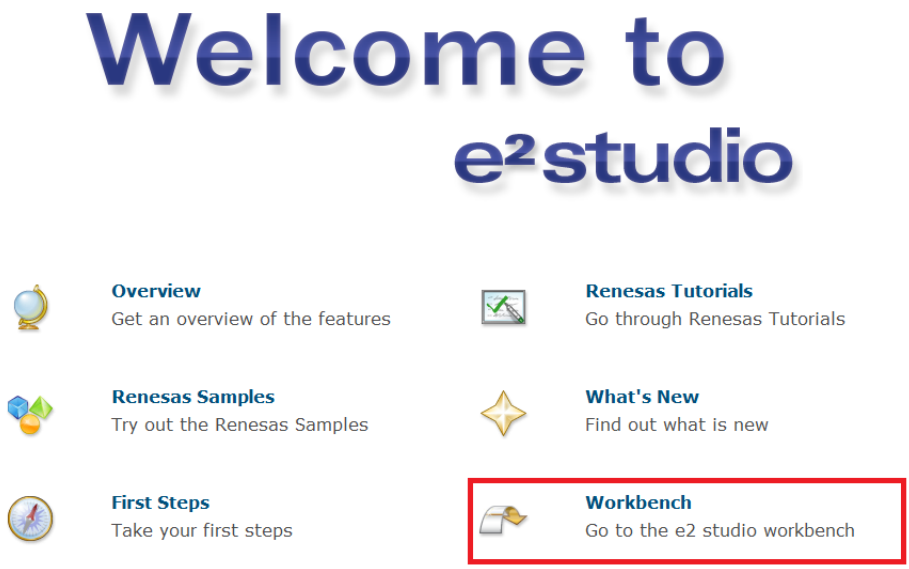
1) Setup e² studio

**a)** Start e² studio

**b)** If you start up e² studio at first, the following dialog is displayed. Specify the folder to store the project in this dialog.



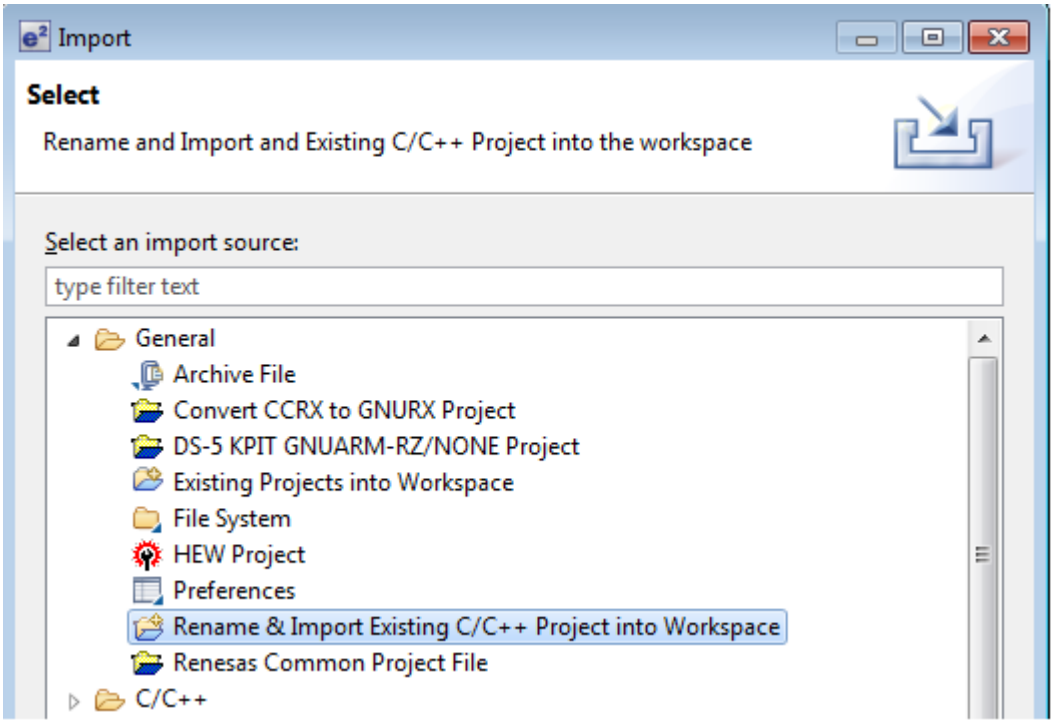

**c)** Click Workbench icon



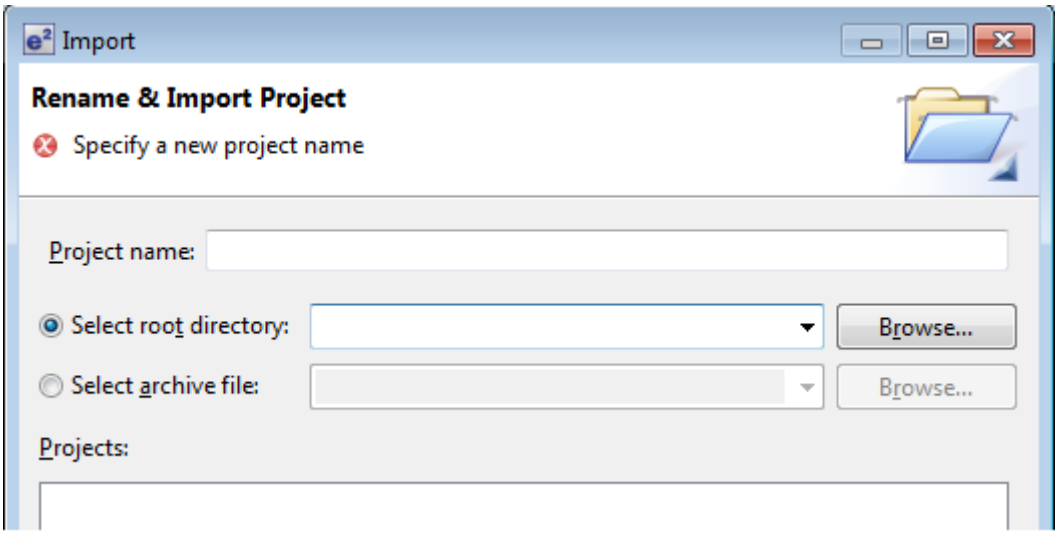
2) Import the project to the workspace

a) Select [File] > [Import]

b) Select "General => Rename & Import Existing C/C++ Project into Workspace"




Select the root directory of the project, that is, the folder containing the ".cproject" file.




c) Click "Finish".

You have now imported the project into the workspace. Note that you can import other projects into the same workspace.

3) Generate the binary target program by clicking the "Build" button.

4) Connect the target board to the debug tool and download the executable. The target is run by clicking the "Run" button.

# 2. Software Configuration

## 2.1 Module Configuration

The PHID comprises a HID class driver as well as mouse and keyboard device drivers. In response to data transfer requests from the APL, it transfers data to the USB host, via the PCD.

Figure 2-1 shows the module configuration of the PHID, and Table 2-1 lists the functions of the modules.

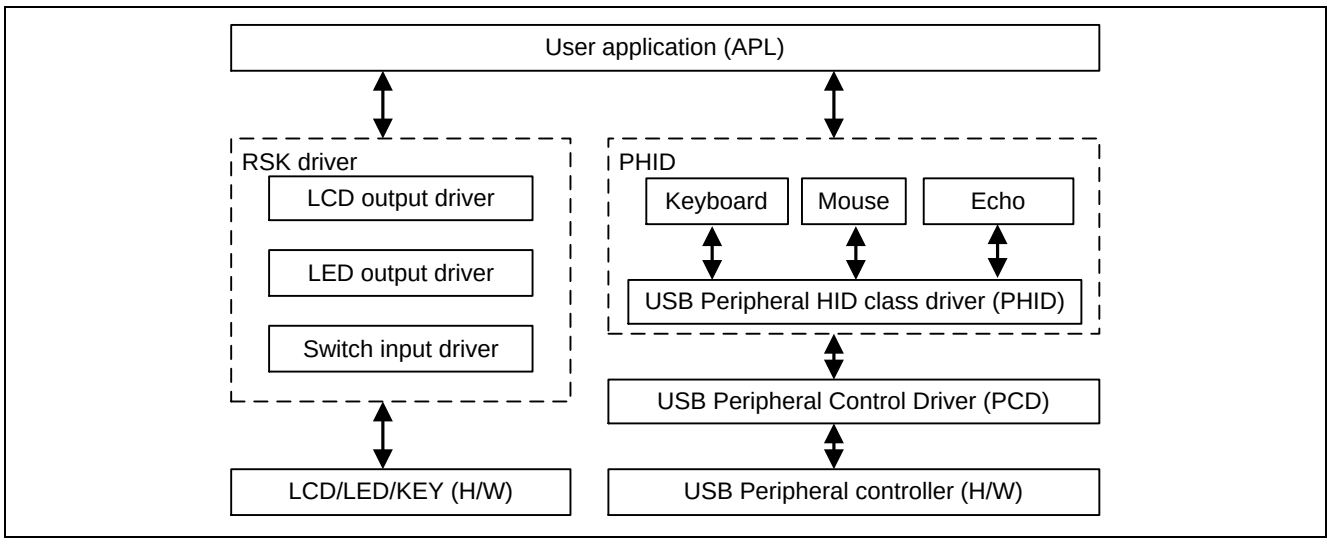



**Figure 2-1 Module Configuration**

**Table 2-1 Function of Moudles**

| Module Name | Function |
|---|---|
| APL | Sample application program |
| RSK driver | Sample application for using the peripheral functions on the RSK board. |
| PHID (r_usb_phidi) | Interprets requests from the HID host.<br>Reports APL key operation information to the HID host, via the PCD. |
| PCD (r_usb_basic) | USB Peripheral Hardware Control Driver |

# 3. Sample Application

## 3.1 Application Specifications

The main functionalities of the PHID sample application (APL) are described below.

### (1). Keyboard Mode: Keyboard Functionality

When the RSK connects to the USB host, the USB host recognizes the RSK as a keyboard. The RSK operates as a keyboard, transmitting keyboard data to the USB host using interrupt IN transfer.

### (2). Mouse Mode: Mouse Functionality

When the RSK connects to the USB host, the USB host recognizes the RSK as a mouse. The RSK operates as a mouse, transmitting mouse data to the USB host using interrupt IN transfer.

### (3). Echo Mode: USB Loopback Functionality (Interrupt IN/OUT Data Transfer)

The RSK connects to the USB host and performs interrupt IN/OUT data transfer. This functionality performs processing to transmit the data received from the USB host back to the USB host unaltered.

### (4). Low-Power-Consumption Functionality

This functionality transitions the microcontroller to a low-power mode according to the USB state. To enable this functionality, set the macro definition USB_CPU_LPW_PP to USB_LPWR_USE_PP in the file r_usb_basic_config.h.

a) In the USB suspend state, the microcontroller transitions to sleep mode.
b) In the USB detached state, the microcontroller transitions to software standby mode.

[Note]

1. Make the selection of keyboard mode, mouse mode, or other mode in r_usb_phid_config.h. For details, see the application note “USB Peripheral Human Interface Device Class Driver for USB Firmware Firmware Integration Technology” (document No. R01AN2663EJ).
2. Echo mode enables communication with USB hosts supporting USB loopback functionality. Keyboard mode and mouse mode enable USB communication with PCs (USB hosts) supporting OSes such as Windows 7, Windows 8, Windows 8.1 and Windows 10.

## 3.2 Overview of Application Processing

The APL consists of two parts: processing of initial settings and the main loop. These are described in outline below.

### 3.2.1 Initial setting

The initial settings include microcontroller pin settings, USB driver settings, and USB controller initial settings.

### 3.2.2 Main loop (Mouse mode)

In Mouse mode the main loop performs the following processing:

a) When enumeration with the USB host finishes, the USB driver calls the function *hid_open*, which is specified by member *devconfig* of structure USB_PCDREG_t. The function *hid_open* sets EVENT_CONFIGURED as the event value.

b) The processing of EVENT_USB_WRITE_START calls the function *R_usb_phid_send_data* to request transmission of mouse data by the USB driver. When transmission of the mouse data finishes, the callback function *hid_write_trans_cb*, specified by the 4th argument of the function *R_usb_phid_send_data*, is called. This callback function sets EVENT_USB_WRITE_COMPLETE as the event value.

c) The processing of EVENT_USB_WRITE_COMPLETE sets the transmission status variable to "not transmitting."

d) The processing of EVENT_SUSPEND calls the function *hid_low_power_control* to transition the HID device (RSK) to the low-power mode (sleep mode). Note that if the HID device (RSK) is in the suspend state, it is woken from the suspend state when a resume signal transmitted by the USB host is detected.

e) The processing of EVENT_NONE captures key input information. When SW1 is pressed:

   i. If the HID device is in the suspend state, a RemoteWakeUp signal is sent to the USB host by means of the *R_usb_phid_ChangeDeviceState* function.

   ii. If the HID device is in the configured state, processing to set the key data (mouse data) is performed and the event value is set to EVENT_USB_WRITE_START in order to transmit the specified data to the USB host. The transmission status variable is set to "transmitting."

f) If the USB host transmits a suspend signal to the HID device (RSK) while steps b) to e) above are being processed repeatedly, the USB driver calls the function *hid_suspend* specified by member *devsuspend* in structure USB_PCDREG_t. The function *hid_suspend* sets EVENT_SUSPEND as the event value.

g) The processing of EVENT_SUSPEND calls the function *hid_low_power_control* to transition the HID device (RSK) to the low-power mode (sleep mode). Note that if the HID device (RSK) is in the suspend state, it is woken from the suspend state when a resume signal transmitted by the USB host is detected.

h) If the HID device (RSK) is detached from the USB host while steps b) to e) above are being processed repeatedly, the USB driver calls the function *hid_close* specified by member *devdetach* in structure USB_PCDREG_t. The function *hid_close* sets EVENT_DETACH as the event value.

i) The processing of EVENT_DETACH calls the function *R_usb_phid_TransferEnd* to transition the HID device (RSK) to the low-power mode (software standby mode) after the data transfer request ends. If the HID device (RSK) is attached to the USB host again, enumeration starts with the USB host and the processing resumes from step a) above.

An outline of the processing of the APL is shown below.

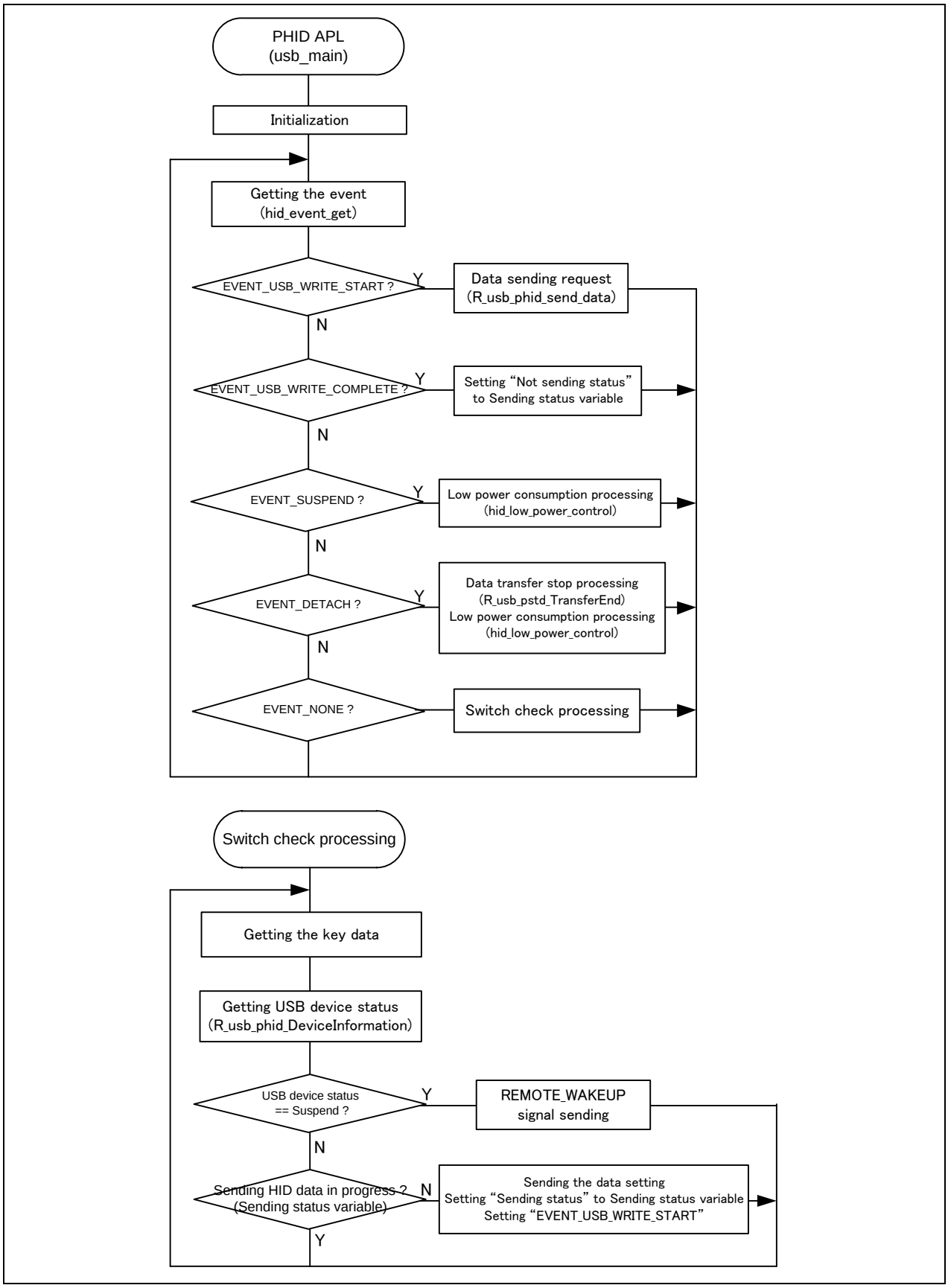



**Figure 3-1 Main Loop Processing (Mouse mode)**

### 3.2.3 Main loop (Keyboard mode)

In keyboard mode the main loop performs the following processing:

a) When enumeration with the USB host finishes, the USB driver calls the function *hid_open*, which is specified by member *devconfig* of structure USB_PCDREG_t. The function *hid_open* sets EVENT_CONFIGURED as the event value.

b) The processing of EVENT_CONFIGURED calls the function *R_usb_phid_receive_data* to request reception by the USB driver of OUT data transmitted by the USB host. When reception of the OUT data finishes, the callback function *hid_read_trans_cb*, specified by the 4th argument of the function *R_usb_phid_receive_data*, is called. This callback function sets EVENT_USB_READ_COMPLETE as the event value.

c) The processing of EVENT_USB_READ_COMPLETE performs LED display processing based on the received OUT data, etc. It also sets EVENT_USB_READ_START as the event value.

d) The processing of EVENT_USB_WRITE_START calls the function *R_usb_phid_send_data* to request data transfer by the USB driver of the key input data, etc., to the USB host. When transmission of the key input data, etc., finishes, the callback function *hid_write_trans_cb*, specified by the 4th argument of the function *R_usb_phid_send_data*, is called. This callback function sets EVENT_USB_WRITE_COMPLETE as the event value.

e) The processing of EVENT_USB_WRITE_COMPLETE:

   i. When transmission of the key input data is finished, it is necessary to transmit data consisting of 8 bytes of zeroes to the USB host to notify it of key release. Processing is performed to set the necessary zero data and the transmission status variable is set to “zero data transmission.” Also, EVENT_USB_WRITE_START is set as the event value.

   ii. When transmission of the zero data is finished, the transmission status variable is set to “not transmitting.”

f) The processing of EVENT_NONE determines whether or not key input has occurred. If the HID device is in the suspend state and SW1 is pressed and then released, a RemoteWakeUp signal is sent to the USB host by means of the *R_usb_phid_ChangeDeviceState* function. If a key other than SW1 is pressed, processing to set the key data takes place and the transmission status variable is set to “transmitting key data.” Also, EVENT_USB_WRITE_START is set as the event value in order to transmit the specified key data to the USB host.

g) If the USB host transmits a suspend signal to the HID device (RSK) while steps b) to f) above are being processed repeatedly, the USB driver calls the function *hid_suspend* specified by member *devsuspend* in structure USB_PCDREG_t. The function *hid_suspend* sets EVENT_SUSPEND as the event value.

h) The processing of EVENT_SUSPEND calls the function *hid_low_power_control* to transition the HID device (RSK) to the low-power mode (sleep mode). Note that if the HID device (RSK) is in the suspend state, it is woken from the suspend state when a resume signal transmitted by the USB host is detected.

i) If the HID device (RSK) is detached from the USB host while steps b) to f) above are being processed repeatedly, the USB driver calls the function *hid_close* specified by member *devdetach* in structure USB_PCDREG_t. The function *hid_close* sets EVENT_DETACH as the event value.

j) The processing of EVENT_DETACH calls the function *R_usb_phid_TransferEnd* to transition the HID device (RSK) to the low-power mode (software standby mode) after the data receive request ends. If the HID device (RSK) is attached to the USB host again, enumeration starts with the USB host and the processing resumes from step a) above.

An outline of the processing of the APL is shown below.

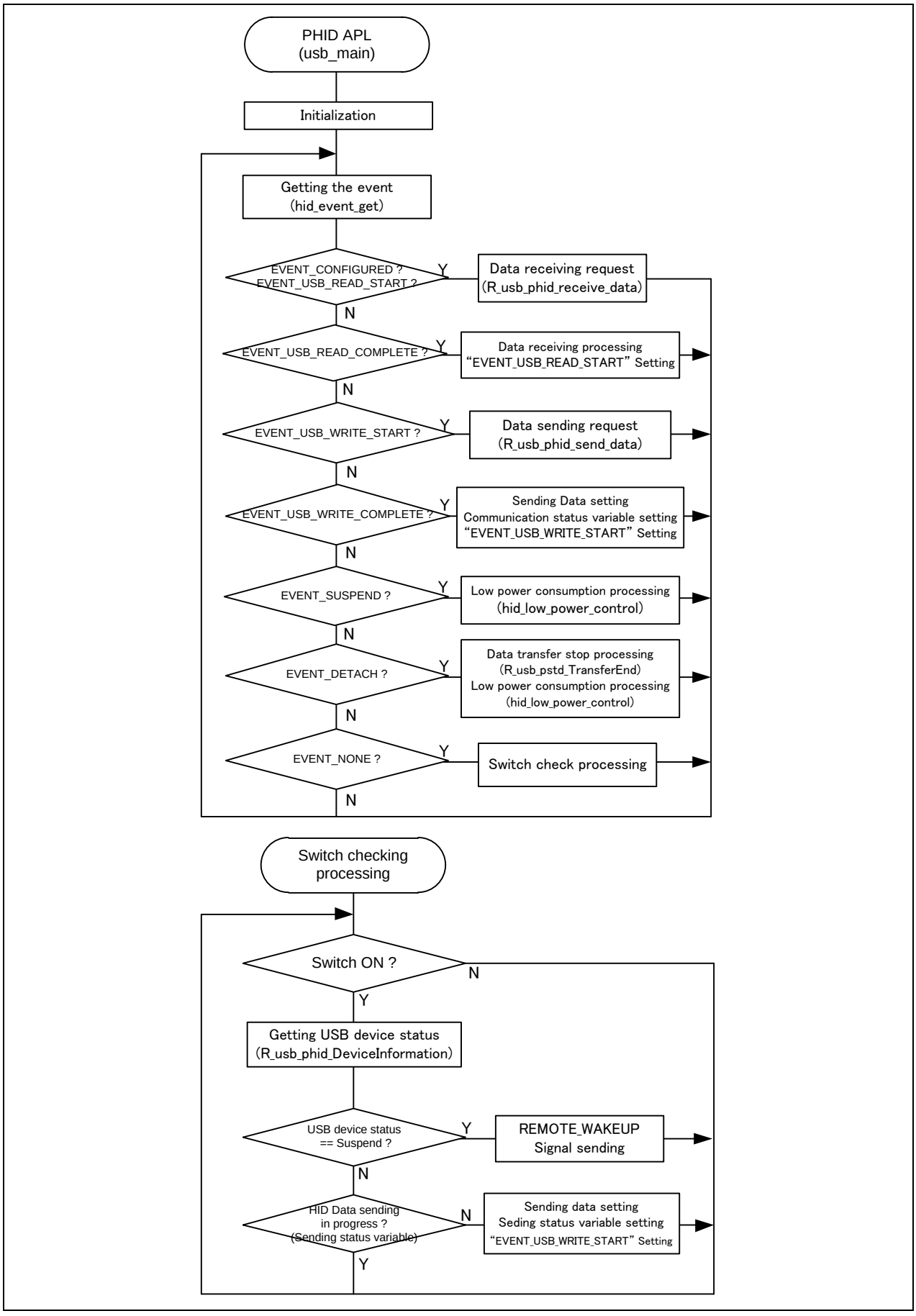



**Figure 3-2 Main Loop Processing (Keyboard mode)**

### 3.2.4 Main loop (Echo mode)

In echo mode the main loop performs the following processing:

a) When enumeration with the USB host finishes, the USB driver calls the function *hid_open*, which is specified by member *devconfig* of structure USB_PCDREG_t. The function *hid_open* sets EVENT_CONFIGURED as the event value.

b) The processing of EVENT_CONFIGURED calls the function *R_usb_phid_receive_data* to request reception of data from the USB host. When reception of the data finishes, the callback function *hid_read_trans_cb*, specified by the 4th argument of the function *R_usb_phid_receive_dat*a, is called. This callback function sets EVENT_USB_READ_COMPLETE as the event value.

c) The processing of EVENT_USB_READ_COMPLETE calls the function *R_usb_phid_send_data* to transmit to the USB host the data received in b) above. When reception of the data finishes, the callback function *hid_write_trans_cb*, specified by the 4th argument of the function *R_usb_phid_send_data*, is called. This callback function sets EVENT_USB_WRITE_COMPLETE as the event value.

d) The processing of EVENT_USB_WRITE_COMPLETE sets EVENT_USB_READ_START as the event value.

e) If the USB host transmits a suspend signal to the HID device (RSK) while steps b) to d) above are being processed repeatedly, the USB driver calls the function *hid_suspend* specified by member *devsuspend* in structure USB_PCDREG_t. The function hid_suspend sets EVENT_SUSPEND as the event value.

f) The processing of EVENT_SUSPEND calls the function *hid_low_power_control* to transition the HID device (RSK) to the low-power mode (sleep mode). Note that if the HID device (RSK) is in the suspend state, it is woken from the suspend state when a resume signal transmitted by the USB host is detected.

g) If the HID device (RSK) is detached from the USB host while steps b) to d) above are being processed repeatedly, the USB driver calls the function *hid_close* specified by member *devdetach* in structure USB_PCDREG_t. The function *hid_close* sets EVENT_DETACH as the event value.

h) The processing of EVENT_DETACH calls the function *R_usb_phid_TransferEnd* to transition the HID device (RSK) to the low-power mode (software standby mode) after the data transfer/receive request ends. If the HID device (RSK) is attached to the USB host again, enumeration starts with the USB host and the processing resumes from step a) above.

An outline of the processing of the APL is shown below.

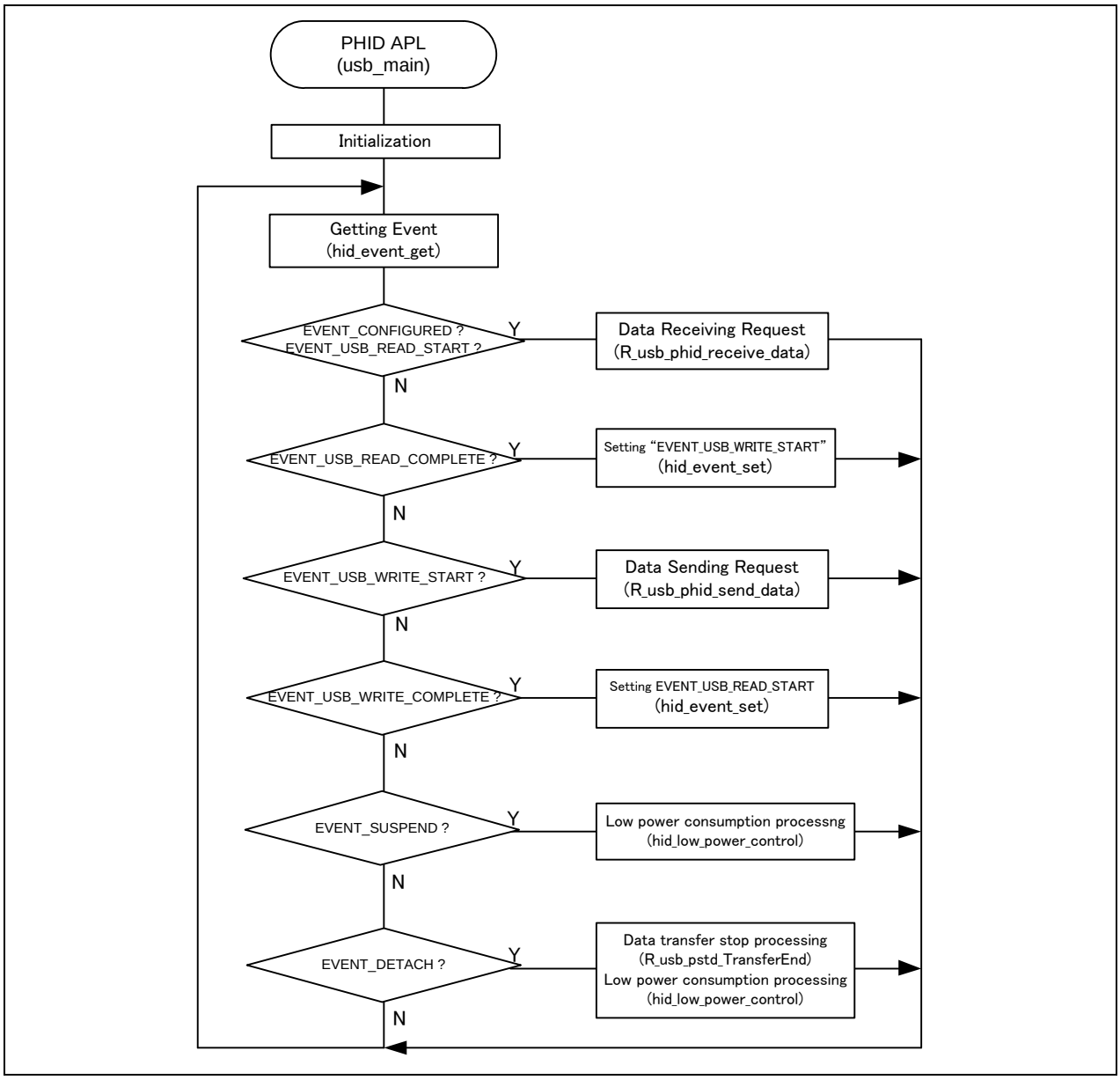



**Figure 3-3 Main Loop Processing (Echo mode)**

**Table 3-1 Event List**

| Event | Description |
|---|---|
| EVENT_CONFIGURD | USB device connecting competion |
| EVENT_USB_READ_START | Data reception request |
| EVENT_USB_READ_COMPLETE | Data reception completion |
| EVENT_USB_WRITE_START | Data transmission request |
| EVENT_USB_WRITE_COMPLETE | Data transmission completion |
| EVENT_SUSPEND | Suspend |
| EVENT_DETACH | USB detach |
| EVENT_NONE | No event |

[Note]

1. If the processing to get the event determines that the event to be fetched is not present, the event is set to "EVENT_NONE."
2. The following events are set by the callback function. The following shows the callback functions set each event

**Table 3-2 Event and Callback Function**

| Event | Callback Function |
|---|---|
| EVENT_CONFIGURD | hid_open |
| EVENT_USB_READ_COMPLETE | hid_read_trans_cb |
| EVENT_USB_WRITE_COMPLETE | hid_write_trans_cb |
| EVENT_SUSPEND | hid_suspend |
| EVENT_DETACH | hid_close |

### 3.2.5 Event Management

Members (event_cnt, event[]) of the following structure are used to manage states and events. This structure is prepared by the APL.

```
typedef struct DEV_INFO                 /* Structure for HID device control */
{
    uint16_t    event_cnt;              /* Event count */
    uint16_t    event[EVENT_MAX];       /* Event. */
} DEV_INFO_t;
```

### 3.2.6 MCU Low power consumption processing

MCU low power consumption processing transitions the MCU to low-power mode when the following conditions are met:

**Table 3-3 Conditions for Transition to Low-Power Mode**

| Transition Condition | | Transition Status |
|---|---|---|
| VBUS | USB State | |
| OFF | – | Software standby mode |
| ON | Suspend Configured | Sleep mode |
| ON | Other than Suspend Configured | Normal mode (program running) |

a) When the device is detached (VBUSOFF), the APL transtions theMCU to software standby mode. Note that recovery from software standby mode occurs when the RSK boardattaches to the USB host, causing a transition to normal mode.

b) When the HID device is suspended, the APL transitions the MCU to sleep mode. Note that recovery from sleep mode occurs when a Resume signal is transmitted by the USB host, causing a transition to normal mode.

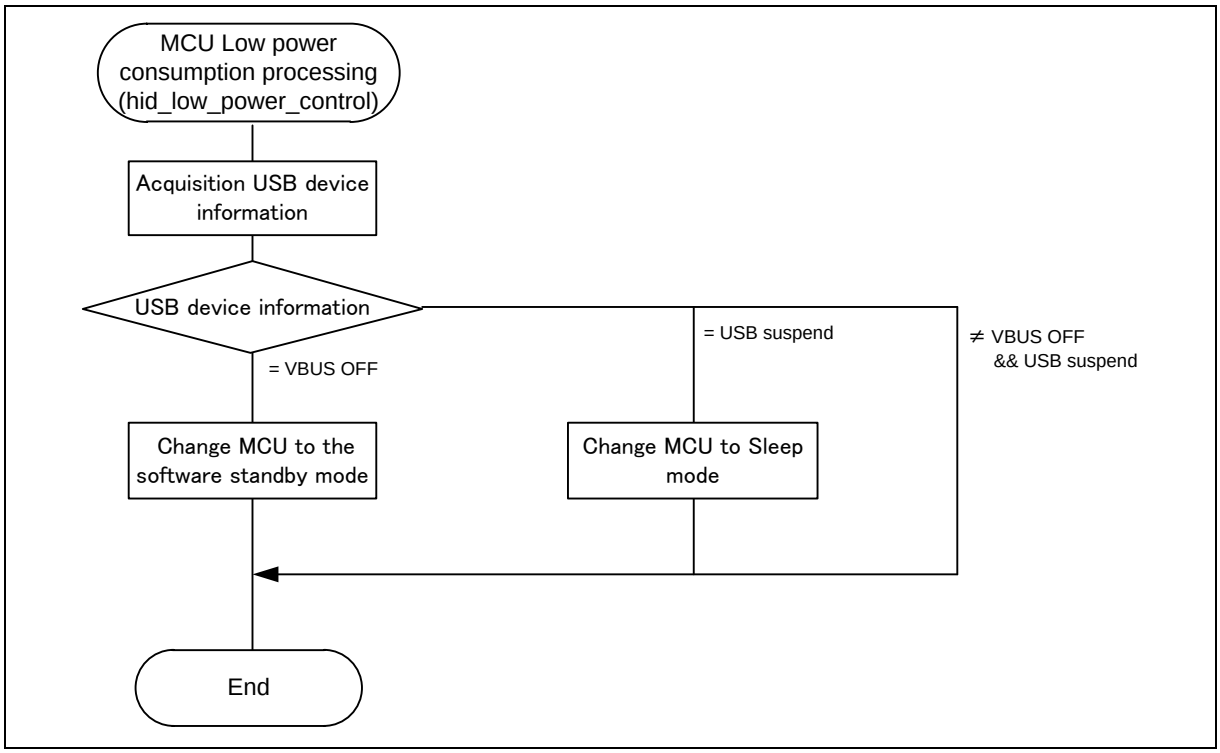



**Figure 3-4 Flowchart of MCU Low Power Consumption Processsing**

## 3.3 Switch

### 3.3.1 Switch specification

The specifications of the switches used in mouse mode and keyboard mode are listed below. The switches on the RSK are not used in echo mode.

Note that the application program does not recognize a switch press as having occurred when the switch is only pressed down. The combination of a switch press and release is recognized as a switch press.

**1) Mouse mode**

| Switch Number | Operation |
|---|---|
| Switch1(SW1) | Left click |
| Switch2(SW2) | Reports motion data for mouse up/down direction. |
| Switch3(SW3) | Reports motion data for mouse right/left direction. |

**2) Keyboard mode**

| Switch Number | Operation |
|---|---|
| Switch2(SW2) | One of the key codes for characters “a” to “z” or “Enter” is reported to the host each time SW is pressed. |
| Switch3(SW3) | One of the key codes for “1” to “9” and “0” or “Enter” is notified to the host each time SW is pressed. |

（Note1） Movement data is generated when a switch is pressed and held, and the data is reported to the host. Data reporting stops when the switch is released. Pressing the switch again switches the movement direction, and movement data reporting continues.

（Note2） When switches 2 and 3 are both unpressed, in keyboard mode NULL data is transferred to the USB host, and in mouse mode no data is transferred to the USB host.

### 3.3.2 Data Format

The table below shows the transmit report format used for sending data to and from USB Host. These data formats are set in conjunction with the HID report descriptor contents notified to USB Host.

**Table 3-4 Data Formats Used when Notifying the Host**

| offset | Mouse Mode (3Bytes) | Keyboard Mode (8Bytes) |
|---|---|---|
| 0 | b0：Button 1<br>b1：Button 2<br>b2：Reserved | Modifier keys |
| 1 | X displacement | Reserved |
| 2 | Y displacement | Keycode 1 |
| 3 | | Keycode 2 |
| 4 | | Keycode 3 |
| 5 | | Keycode 4 |
| 6 | | Keycode 5 |
| 7 | | Keycode 6 |

**Table 3-5 Keyboard OUTPUT Report format**

| offset (byte) | Value |
|---|---|
| 0 | b0：LED 0 (NumLock)<br>b1：LED 1 (CapsLock)<br>b2：LED 2 (ScrollLock)<br>b3：LED 3 (Compose)<br>0: OFF, 1: ON |

## 3.4 Descriptor

The PHID’s descriptor information is contained in r_usb_phid_descriptor.c. Also, please be sure to use your vendor ID.

# 4. Class Request

Table 4-1 shows the class requests supported by PHID.

**Table 4-1 Supported Basic Requests and HID Class Requests**

| Request | Code | Description | Supported |
|---|---|---|---|
| Get Report | 0x01 | Sends a report to the USB Host | YES |
| Set Report | 0x09 | Receives a report from the USB Host | YES |
| Get Idle | 0x02 | Sends a duration (time) to the USB Host | YES |
| Set Idle | 0x0A | Receives a duration (time) from the USB Host | YES |
| Get Protocol | 0x03 | Sends a protocol to the USB Host | NO |
| Set Protocol | 0x0B | Receives a protocol from the USB Host | NO |
| Get Report Descriptor | Standard | Sends a report descriptor to the USB Host | YES |
| Get HID Descriptor | Standard | Sends an HID descriptor to the USB Host | YES |

## 5. Using the e² studio project with CS+

The PHID contains a project only for e² studio. When you use the PHID with CS+, import the project to CS+ by following procedures.

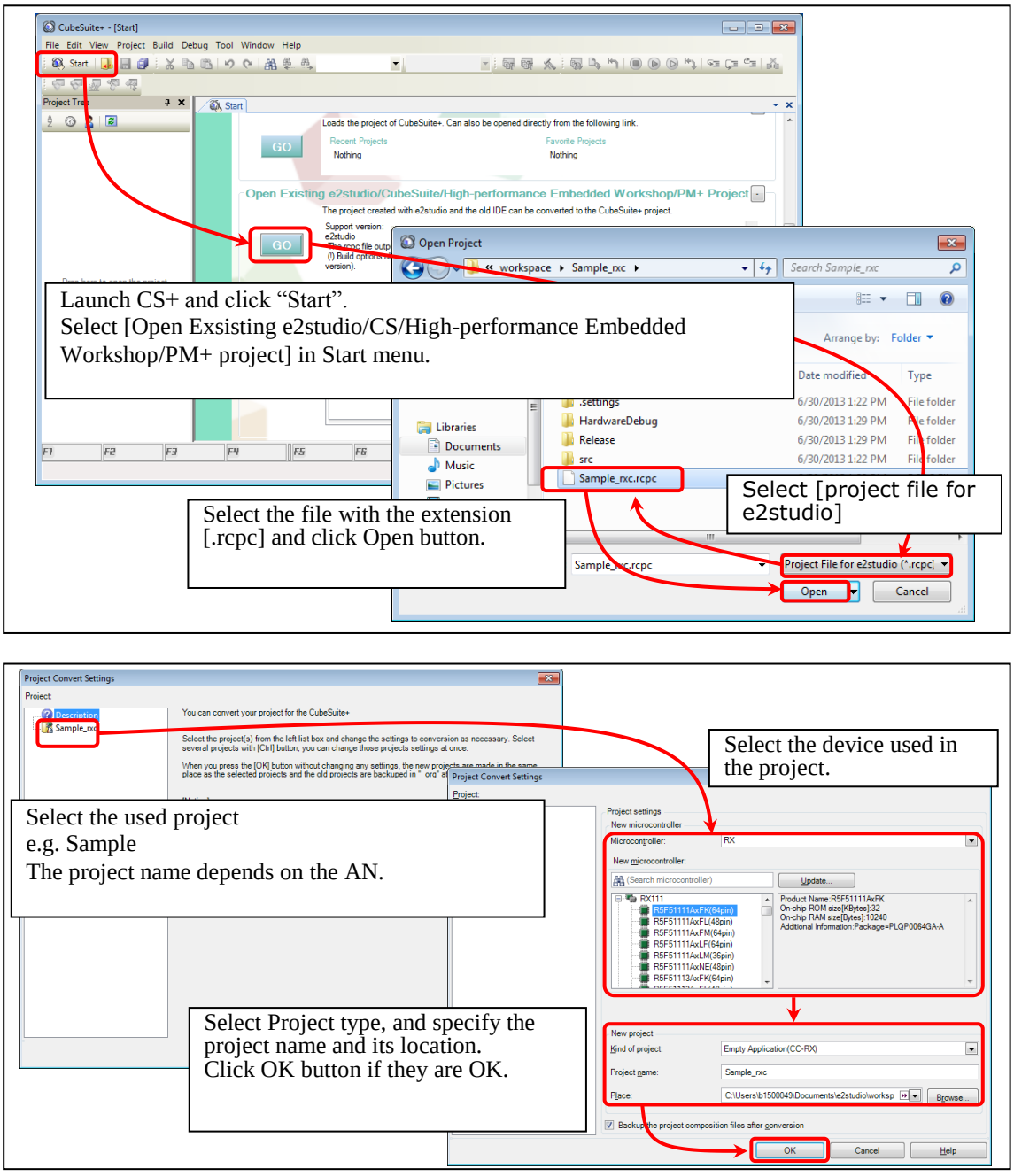



**Figure 5-1 Using the e² studio project with CS+**

## Website and Support

Renesas Electronics Website
http://www.renesas.com/

Inquiries
http://www.renesas.com/inquiry/

## Revision Record

| Rev. | Date | Description | |
|---|---|---|---|
| | | Page | Summary |
| 1.11 | Sep 30, 2015 | — | First Edition Issued. |
| | | | |
| | | | |
| | | | |

## General Precautions in the Handling of MPU/MCU Products

The following usage notes are applicable to all MPU/MCU products from Renesas. For detailed usage notes on the products covered by this document, refer to the relevant sections of the document as well as any technical updates that have been issued for the products.

1. Handling of Unused Pins

   Handle unused pins in accordance with the directions given under Handling of Unused Pins in the manual.

   — The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible. Unused pins should be handled as described under Handling of Unused Pins in the manual.

2. Processing at Power-on

   The state of the product is undefined at the moment when power is supplied.

   — The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the moment when power is supplied.
   In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the moment when power is supplied until the reset process is completed.
   In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the moment when power is supplied until the power reaches the level at which resetting has been specified.

3. Prohibition of Access to Reserved Addresses

   Access to reserved addresses is prohibited.

   — The reserved addresses are provided for the possible future expansion of functions. Do not access these addresses; the correct operation of LSI is not guaranteed if they are accessed.

4. Clock Signals

   After applying a reset, only release the reset line after the operating clock signal has become stable. When switching the clock signal during program execution, wait until the target clock signal has stabilized.

   — When the clock signal is generated with an external resonator (or from an external oscillator) during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Moreover, when switching to a clock signal produced with an external resonator (or by an external oscillator) while program execution is in progress, wait until the target clock signal is stable.

5. Differences between Products

   Before changing from one product to another, i.e. to a product with a different part number, confirm that the change will not lead to problems.

   — The characteristics of an MPU or MCU in the same group but having a different part number may differ in terms of the internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.

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